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Impact of climate-related changes to the timing of autumn foliage colouration on tourism in Japan

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A R T I C L E   I N F O

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A B S T R A C T

This study introduces plant phenophase as a “bridge” to assessing the impact of climate change on autumn foliage viewing tourism in Japan. The results showed that from 1978 to 2016, the autumnal foliage colouration of four cities in Japan was delayed, the duration of the autumnal leaf discolouration was significantly shortened, and only one city experienced a significant delay in leaf-falling. The delay in the autumn foliage colouration and leaf-falling periods on average increase the December maple viewing tourism volume by 3.64% and 3.02%, respectively. The impact on autumn maple foliage viewing tourism volume also has a 1-year delay effect, and the maple foliage phenophase of different cities have significantly varied influence on maple foliage viewing tourism volume. Overall, the change in the timing of maple leaf discolouration has been advantageous to the Japanese maple tourism industry.

1. Introduction

Annually, as the weather gradually cools, the leaves of plants of the Aceraceae family change from green to yellow to a deep red hue. The leaf discolouration process continues for several weeks. This is the start of the annual maple foliage viewing period in Canada, the New England region of the US, Bavarian Germany, and Beijing China (Inoue & Nagai, 2015). In Japan, autumn foliage viewing is in the same league as that for the legendary cherry blossoms. Autumn maple foliage viewing is referred to as 'Momijigari'. Since the 17th century, ordinary Japanese citizens have been travelling to view maple foliage, which is one of the activities that best represents Japanese autumn tourism. Currently, the autumn foliage culture has spread to Japanese haiku, noh theatre, diets, and other aspects of life. The period between October and December of every year is commonly referred to as the “Momijigari” period in Japan. Many tourist destinations hold the "Momiji Matsuri" (JNTO). Annually, tourist destinations for maple foliage viewing attract numerous tourists, who bring substantial economic benefits. In November 2016, the total number of visitors to Takamatsu Kurimori Park in Southwest Japan reached 98,556 people (Kagawa Prefecture Visitors Dynamics Investigation Reports, 2016).

Maple foliage viewing tourism activities are considerably temporally restricted. The plant phenophase has a significant impact on the start of autumn foliage viewing, duration, visitor experience, and other such factors. Plant phenophase is very sensitive to climate change (Richardson et al., 2013), which may affect autumn foliage viewing tourism by altering the plant leaf phenophase.

In this study, six maple viewing locations in Japan with the longest developed autumn foliage viewing tourism industry, tourism scale, and those that best represent the activity were used as subjects to address the following questions. First, does the climate-related change in autumn foliage phenophase affect the volume of maple viewing tourism? Second, are there differences in the impact of changes in autumn foliage phenophase on different maple viewing scenic spots? Third, what is the mechanism by which the changes in autumn foliage phenophase affect the autumn foliage viewing tourism industry?

Recently, Japan has experienced notable climate change with increases in the annual average temperature of 1.19 °C per century and a temperature increase of 1.20 °C per century in autumn (JMA, 2017). Since the late 1980s, Japan has shown a rapid climatic warming trend. In the 50 years from 1953 to 2003, the foliage discolouration and leaf-falling periods of Japanese maple trees have been delayed by 15.6 and 9.1 days respectively (JMA, 2007). Therefore, the study of the impact of changes in autumn foliage phenophase on the autumn foliage viewing tourism industry and the identification of the regions where the autumn foliage viewing tourism industry is most sensitive to climate change could help stakeholders understand the impact of climate change on the maple foliage viewing tourism industry. Furthermore, this information could provide a scientific basis for stakeholders to propose effective strategies for adaptation.

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2. Literature review

Although the impact of climate change on tourism has been widely confirmed, it has not been fully understood due to some uncertainties. First, there is uncertainty caused by the impact of climate change on different types of tourism activities. From the evidence of climate change impact on tourism in The Intergovernmental Panel on Climate Change (http://www.ipcc.ch/report/ar5/syr/) assessment report, the same climate change may have opposite effects on different types of tourism activities in the same region. For example, in the Alps region, the increase in temperature has had a negative impact on winter ski tourism (Klein, Vitasse, Rixen, Marty, & Rebetez, 2016), but a favourable impact on general tourism activities due to the extension of the tourism season (Camille, 2013). Considering the variety of tourism activities, it is necessary to carry out separate and specific analyses and assessments of some typical tourism activities that have widespread influence. The existing research has focused on winter skiing (Camille, 2013; Liu et al., 2017) and coastal tourism (Fan, Liu, & Quansheng, 2017; Hassanali, 2017; Schliephack & Dickinson, 2017; Toimil, Díaz-Simal, Losada, & Camus, 2018) but not on the impact on plant appreciation tourism. Therefore, it is essential to carry out specific studies on maple leaf tourism in autumn, as it is a globally popular tourism activity. Second, there is the uncertainty caused by regional differences. The impact of climate change varies greatly on the same types of tourism activities in different regions. Currently, in terms of geographical regions, there are many in-depth studies in Europe (Amelung & Moreno, 2012; Malatinszky, Ádám, Falusi, Saláta, & Penksza, 2013), Canada (Hewer & Gough, 2017; Rutty et al., 2017), the United States (Dawson & Scott, 2013; Atzori, Fyall, & Miller, 2018), Australia (Goldberg et al., 2016) and New Zealand (Mackintosh et al., 2017), but relatively few studies in Asia (Ge, Dai, Liu, Zhong, & Liu, 2013). In Japan, a country that has experienced significant climate change, analyses on long-term serial data have revealed the impact of climate change on tourism. These results can be used for comparative analysis and help increase the reliability of assessing the impact of climate change on tourism within the scientific community.

Changes in plant phenophase resulting from the interannual variability of climatic factors such as temperature and precipitation have been widely studied (Gunderson et al., 2012; Ibanez et al., 2010; Piao et al., 2015). However, because of the complexity of autumn phenology and its drivers (Estiarte & Peñuelas, 2015), the number of autumn phenology-related studies has been less than half that of spring phenology, and the study of autumn phenology and its effects have been largely ignored (Gallinat, Primack, & Wagner, 2015). In the Northern Hemisphere, the autumn phenophase was on average postponed by 0.18 ± 0.38 days per year. The impact of different regional, temperature, precipitation, and other meteorological factors on the autumn phenology has not been consistent (Liu et al., 2016). The leaf-falling periods of European beech and quercus have been delayed by 1.4–2.3 days every 10 years (Vitasse et al., 2011). In Japan, elevated temperatures in autumn delay the foliage phenophase, which is more responsive to climate change at low altitudes than at high latitudes (Doi & Takahashi, 2008). Research studies on the effects of climate change on plant blooming and the leaf discolouration period have been more in-depth. However, studies on the impact of plant phenophase changes on human tourism are still relatively few, and related research on the autumn leaf discolouration period is still more scarce.

A few studies have explored the possible impact of climate change-altering phenophase on plant viewing tourism. The opening dates of the flower festivals in many regions do not match the actual flowering dates because of the lack of forecasts (Sparks, 2014; Wang, Ning, Wang, & Ge, 2017). In each of the 12 cities in China, the best foliage viewing period of leaf discolouration has been delayed for 2.98 days for every 1 °C increase in temperature over the past 50 years. Among them, the peaks of leaf discolouration in Beijing and Xi'an were delayed by an average of 0.16 and 0.21 days per year, respectively (Tao, Ge, Wang, & Dai, 2015). The economic benefits of the Sakura Festival operators have also been negatively affected by climate change (Sakurai et al., 2011). These studies speculated only on the possible impact of plant phenophase on the timing and income of these viewing activities but did not quantify the impact of phenophase changes on the number of tourists. The impact of climate-related changes in plant phenophase on tourism activities also needs more accurate analysis and demonstration in more regions. The changes in the leaf phenophase of autumn plants, especially those people flock to view, such as maple trees, and the impact mechanisms on plant viewing tourism also requires further study.

Compared with the existing studies, the contributions of this article are as follows: first, this study focuses on Japan, where climate change has been significant, and investigates the sensitivity of the popular maple leaf tourism in autumn to climate change. Our research helps reduce the uncertainty in the impact of climate change on tourism caused by differences in tourism types and regions. Second, existing studies in the field of phenology focus more on the ecological and environmental effects resulting from the changes in phenological phases and less on the effects of vegetation changes on human economic activities. Our study provides perspectives to study tourism and climate change with the use of long-term, time-series phenological data, which helps resolve the lack of observational data in tourism research and further deepens the study of the relationship between tourism and climate change. At the same time, it expands the field of phenology.

3. Study area

The study selected the following six sites in four cities (34 °N-45 °N) in the mid-latitude region of Japan (24 °N-45 °N), Shosen kyo Valley and Art Park in Kofu, Shirotori Garden and Higashiyama Zoo and Botanical Gardens in Nagoya, Okayama Korakuen and Ritsurin Park in Takamatsu (Fig. 1). All scenic maple attractions were chosen from the 2017 Japan Maple Tours website (http://www.nihon-kankou.or.jp/kouyou/). Shosen kyo Valley is known as Japan's number one valley, and was ranked eighth in Japan's National Maple Viewing in 2017. The Art Forest Park is famous for the Yamanashi Prefectural Art Museum, which features a combination of artistic and natural beauty. Shirotori Garden is the only large-scale courtyard in Nagoya with famous attractions such as pavilions and suikinkutsu. It has beautiful scenery all year round. Higashiyama Zoo and Botanical Gardens is the ninth most visited maple attraction in Aichi Prefecture. There are botanical gardens, a zoo, amusement park, courtyard, and other areas for excursions. Okayama Korakuen is one of Japan's three most famous parks. Among them, the maple forest is one of the most popular attractions in the park. Ritsurin Park ranks number one in Kagawa Prefecture for viewing maple foliage and has a nearly 400-year-old famous tour around the renowned garden. Furthermore, Shosen kyo Valley, Ritsurin Park, and Okayama Korakuen are all classified as examples of the 36 special attractions in Japan.

4. Methodology

4.1. Research data

The study selected autumn foliage colouration and leaf-falling dates of Kofu, Nagoya, Okayama, and Takamatsu from 1978 to 2016 to analyse the annual change of phenophase. The observed species was maple, and the autumn foliage colouration represented the date when most of the leaves of the observed plants turned red. The leaf-falling period was the date when 80% of the leaves of the plant were observed to have fallen. Phenological data was obtained from the Japan Meteorological website (http://tenki.wet.co.jp/kisetsu/index.html). All data analyses used those of October 1 as the benchmark data and all subsequent data were modified for uniformity (i.e. 30 represents October 31). Due to the limited data on yearly tourist volume statistics, the tourist volume in November and December in the six scenic spots

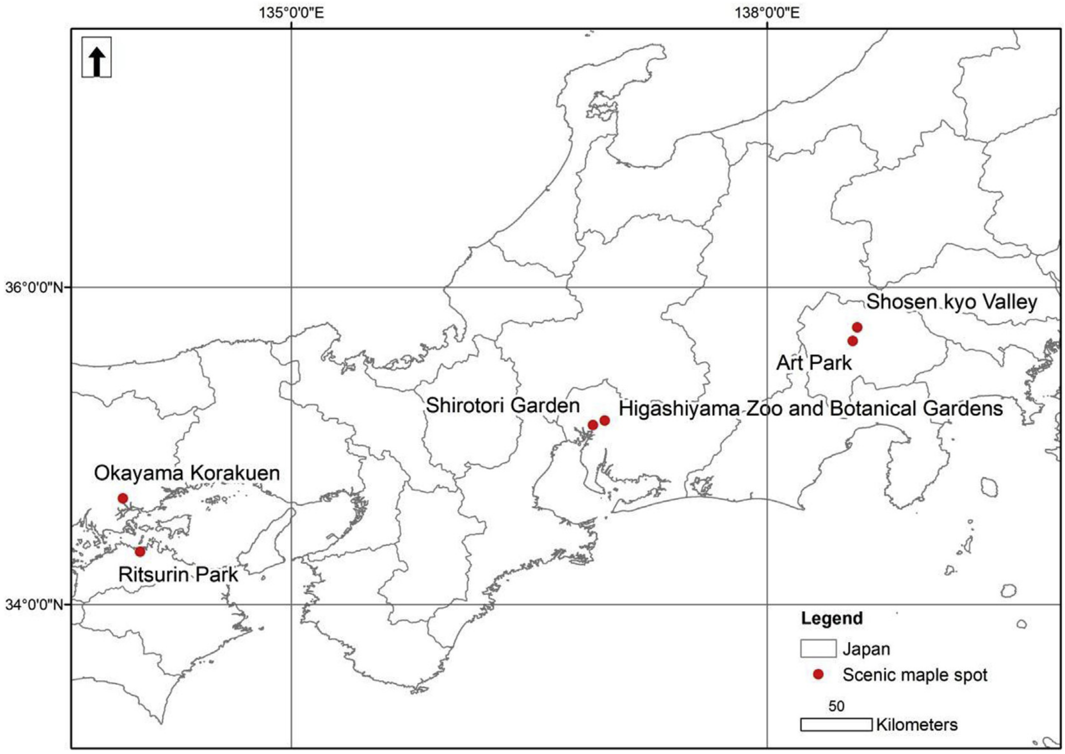

Fig. 1. Six study sites in Japan.

from 2006 to 2015 were selected. The data on tourist volume was retrieved from the official tourism authorities of the respective regions.

During 2006–2015, the average autumn foliage colouration date of Kofu, Nagoya, Okayama, and Takamatsu were 12/1, 11/27, 11/29, and 11/29, respectively; the average leaf-falling periods were 12/9, 12/8, 12/8, and 12/7, respectively, and the average autumn foliage colouration duration was 7.9, 11.4, 9.3, and 8.4 days respectively. According to the statistics of tourists in each scenic spot (Tables 1 and 2), there were more tourists in Art Forest Park than the other sites, whereas Shirotori Garden had the least tourists.

4.2. Annual phenophase changes

To understand the year-on-year variability of leaf phenophase, we analysed the phenological data using the gradient of change, moving average of 5a, and the Mann-Kendall detection method (M-K method). This study used the following linear equation to describe the changing trend of each variable quantitatively:

$$y = a_1 + a_2 x$$

y and x denote phenology date and year, respectively. The trend of change rate equation is $dy/dx = a_2$, where a_2 is the trend rate. The coefficient in the equation was determined using the least square method or empirical orthogonal polynomials. This study used the least squares method to determine the coefficients. When the trend coefficient is positive, it indicates that the red leaf and leaf fall stages are postponed as years progress, or the duration of red leaves is prolonged; when the trend coefficient is negative, it means that the red leaf and leaf fall stages advance as years progress, or the duration of red leaves shortens. By combining the 5a moving average chart, we arrived at the status of the year-on-year variability of leaf phenophase.

Table 1
Statistical description of visitors to the study area in November (unit: person).

	Mean	Std.Dev.	Max	Min
Kofu_SKV	553380.30	566071.48	1353537	103139
Kofu_AP	593181.90	324224.37	1234779	333881
Nagoya_SG	32098.40	15076.93	66268	14538
Nagoya_HZBG	238182.70	29619.57	282546	190163
Okayama_K	79770.00	12278.30	104386	69057
Takamatsu_RP	80003.60	6554.84	94114	72972

(Kofu_SKV, Kofu_AP, Nagoya_SG. agoya_HZBG, Okayama_K, Takamatsu_RP denote Shosen kyo Valley, Art Park, Shirotori Garden, Higashiyama Zoo and Botanical Gardens, Okayama Korakuen and Ritsurin Park, respectively. The following is same as these.).

Table 2
Statistical description of visitors to the study area in December (unit: person).

	Mean	Std.Dev.	Max	Min
Kofu_SKV	117950.20	110541.46	286535	28661
Kofu_AP	273211.40	163814.44	583389	123872
Nagoya_SG	8749.30	3235.63	16006	4468
Nagoya_HZBG	89105.30	20469.89	131694	65090
Okayama_K	30574.00	4121.92	39426	25567
Takamatsu_RP	32065.30	3737.28	38325	28406

To further clarify the leaf phenophase trends and mutation time points, the non-parametric M-K method was used. The advantage of this method is that it does not require samples to follow a certain distribution and is not disturbed by a few abnormal values. It is recommended by the World Meteorological Organization and has been widely used to analyse precipitation, runoff, temperature, and other time series.

Considering a time series data set of $x_1, x_2, \ldots, x_n$ and assuming that the samples are in a stationary random sequence, the sequence values should be independent, and the probability distribution should be the same.

S_k denotes the cumulative value of the ith sample $x_i > x_j (1 \le j \le i)$ and r_i is the total number between 1 and i that is less than x_i, defines the statistic:

$$r_i = \begin{cases} +1 & when\ x_i > x_j \\ 0 & otherwise \end{cases} S_k = \sum_1^k r_i$$

Under the null hypothesis, when $x_1, x_2, \ldots, x_n$ are independent of each other, and are in continuous and identical distributions, expected value and variance of S_k can be defined:

$$E[S_k] = k(k-1)/4$$

$$\mathrm{var}[S_k] = k(k-1)(k-2)/72\ (1 \le k \le n)$$

Standardizing S_k, and the statistic (UF_k) is defined as:

$$UF_k = (S_k - E[S_k])/\sqrt{var(S_k)}$$

When $UF1 = 0$. If UF_k, the value is > 0, and then the sequence shows an upward trend, whereas a value < 0 indicates a downward trend while $UF_k > 1.96$ or $UF_k < -1.96$ indicates that a significant upward or downward trend (significance at 5% levels). The UF_k values of the continuous statistics are plotted as curve *UF* along the time axis. Then reverse the sequence $x_1, x_2, \ldots, x_n$ and calculated the new sequence followed the preceding step to obtained the $U'F_k$ value, and the $U'F_k$ values are plotted as curve *UB* on the same plot. If the intersection of curve *UF* and *UB* is within the confidence interval of ± 1.96 (confidence level [CI], 0.05), then the intersection is the point of mutation and could be used to determine the mutation of the series. Further, if the two curves after intersection have a confidence level of 0.05 (on the side > 0), then there is a changing trend in the series.

4.3. Seemingly unrelated regression (SUR) model

This study used a seemingly unrelated regression (SUR) model to analyse the impact of the phenophase changes on tourist volume. This method includes both heteroscedasticity and the correlation of error and aggregation bias of each equation in the model (Ozturk, 2017). Falk used the SUR model to study the influence of summer weather conditions on the overnight visitor flow in Austria and Germany (Falk, 2015) and the influence of ice and snow depth and economic factors on the demand for downhill skiing in Sweden (Falk & Hagsten, 2016). Pacheco also used this model to study the economic drivers of the revenue per available room in Portuguese hotels (Pacheco, 2016).

To improve the stability of the data, logarithmic processing was first conducted on all the time series (Thrane, 2015). The tourists in all regions are mostly integrated time series and, therefore, we combined it with the Augmented Dickey-Fuller Test results, which enabled us to process all the time series data for a 1-year difference, and the influence of seasonal fluctuations of the tourist flow was eliminated. Because of the differential processing, long-term impact factors (such as real income and prices) on tourism demand could not be fitted. SUR models can incorporate these common impact factors (e.g. economic crisis) using the interrelated deviations of each area.

First, a first-order logarithmic linear regression model was established assuming that the change in tourist flow could be represented using a linear function, which includes the phenophase factor. The model was divided into November, December, and the individual attractions:

$$\triangle \ln Y_{it} = \beta_{0i} + \beta_{1i} \triangle \ln P_{it} + \beta_{2i} \triangle \ln P_{it-12} + \varepsilon_{it}$$

where, $i = 1, \ldots, 6$ represents the urban area, $t = 2006, \ldots, 2015$ represents either November or December, Y represents the number of tourists in each scenic spot, and P represents the phenophase (autumn foliage colouration and leaf-falling periods). In addition, P_{it-12} indicates the same month of the previous year. The coefficients β_{1i} and β_{2i} are a measure of the impact on the phenophase of the current and next year, respectively. The ε_{it} is the error term assumed to be independent and identically distributed. Since first-order logarithms represent the independent variables, the estimated coefficient could be understood to have short-term elasticity. For example, β_2 is understood as the early phenophase of the previous year, leading to a decrease of tourists in the current year. Finally, we used the SUR of Zellner (1962), which allows for significant residual correlation between different urban areas in several regions. The formula is as follows:

$$\triangle lnY_{it} = \widetilde{\beta}_{0i} + \widetilde{\beta}_{1i} \triangle \ln P_{it} + \widetilde{\beta}_{2i} \triangle \ln P_{it-12} \widetilde{\varepsilon}_{it}$$

where, the error term is assumed to have the covariance σ_{ij}; $\mathrm{var}\varepsilon_{it} = \sigma_i^2$, $cov(\varepsilon_{it}\varepsilon_{jt}) = E(\varepsilon_{it}\varepsilon_{jt}) = \sigma_{ij}$, $t = 1,2, \ldots, T$ and $cov(\varepsilon_{it}\varepsilon_{js}) = E(\varepsilon_{it}\varepsilon_{is}) = 0$ ($t \neq s$). The ordinary least squares (OLS) and SUR results were the same only when the explanatory variables were the same for each city in each region.

5. Results

5.1. Annual variation trend of maple leaf phenology

From 1978 to 2016, the autumn foliage colouration period of the four cities showed a delayed trend. The autumn foliage colouration periods of Kofu, Okayama, and Takamatsu were significantly delayed by 4.1, 1.7, and 5.5 days every 10 years. Only the autumn foliage falling period in Takamatsu was significantly delayed by 4.1 days every 10 years. The duration of autumn foliage colouration in the four cities was significantly shortened by 4.0, 1.5, 2.3, and 4.1 days every 10 years, respectively (Table 3).

The moving average of 5a shows that from 2006 to 2015, the autumn foliage colouration of the four cities appeared later than the average of the previous years; however, regarding leaf-falling, only Takamatsu exhibited a later than average defoliation. The autumn foliage colouration durations of all the cities were generally shorter than the average (Fig. 2).

In the past 10 years, the maple foliage colouration of four cities was significantly delayed, the duration was significantly shortened, and the change in the timing of leaf-falling was not significant. The M-K test showed that the foliage colouration period of Kofu mutated around 1997, and that of Takamatsu mutated significantly approximately in 2002. In 2006–2015, the foliage colouration period of the four cities showed a delayed trend. Specifically, the foliage colouration period of Kofu and Takamatsu showed a significantly delayed trend ($\alpha < 0.05$, Fig. 3). In contrast, the leaf-falling period of the four cities did not exhibit a significantly delayed trend. From 2006 to 2015, the leaf-falling period of Kofu changed significantly around 2012, and the delayed trend changed to an early trend in 2013. The leaf-falling period in Nagoya and Okayama showed small changes and a trend of earlier occurrence, whereas that of Takamatsu exhibited a delayed trend. The autumn foliage colouration duration of Kofu, Nagoya, Okayama, and

Table 3
Inter-annual trends of date of leaf phenology characteristics of the study area from 1978 to 2016.

Phenological period	Coefficient	Kofu	Nagoya	Okayama	Takamatsu
foliage colouration period	Mean (day)	55.76	55.56	58.24	49.10
	Std.Dev. (day)	7.27	7.35	5.75	8.79
	Trend (day/year)	0.41***	0.17	0.17**	0.55***
foliage leaf-falling period	Mean (day)	74.45	69.21	70.66	62.90
	Std.Dev. (day)	8.46	8.03	5.23	5.78
	Trend (day/year)	0.01	0.02	−0.06	0.14*
foliage colouration duration	Mean (day)	18.68	13.64	12.59	13.79
	Std.Dev. (day)	9.35	4.25	5.20	6.01
	Trend (day/year)	−0.402***	−0.153***	−0.23***	−0.41***

*,**,*** indicate significance at the 10, 5% and 1% levels, respectively.

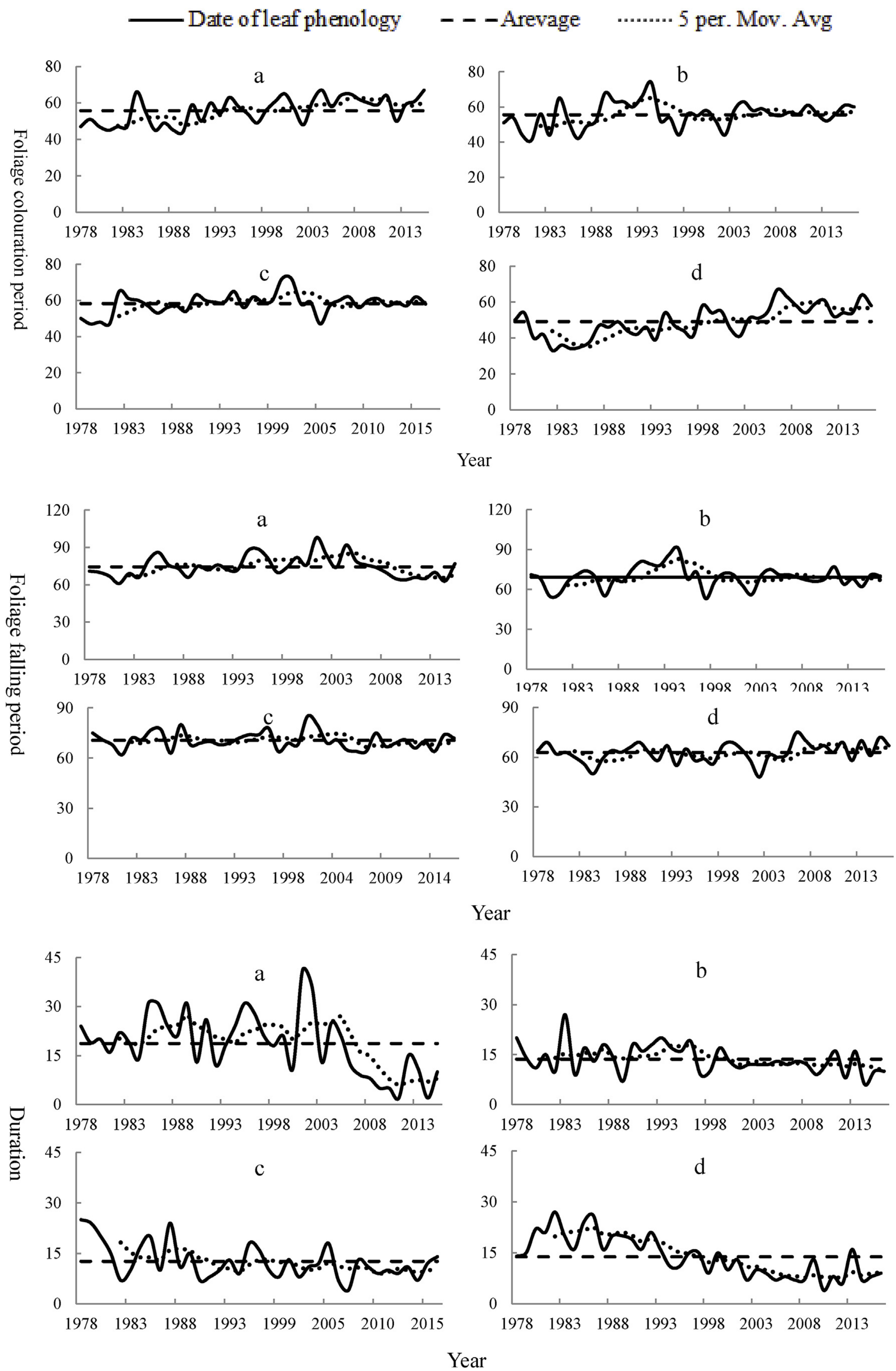

Fig. 2. Five-year moving average of leaf phenology characteristics of the study area from 1978 to 2016. a, b, c, d denote Kofu, Nagoya, Okayama, and Takamatsu respectively.

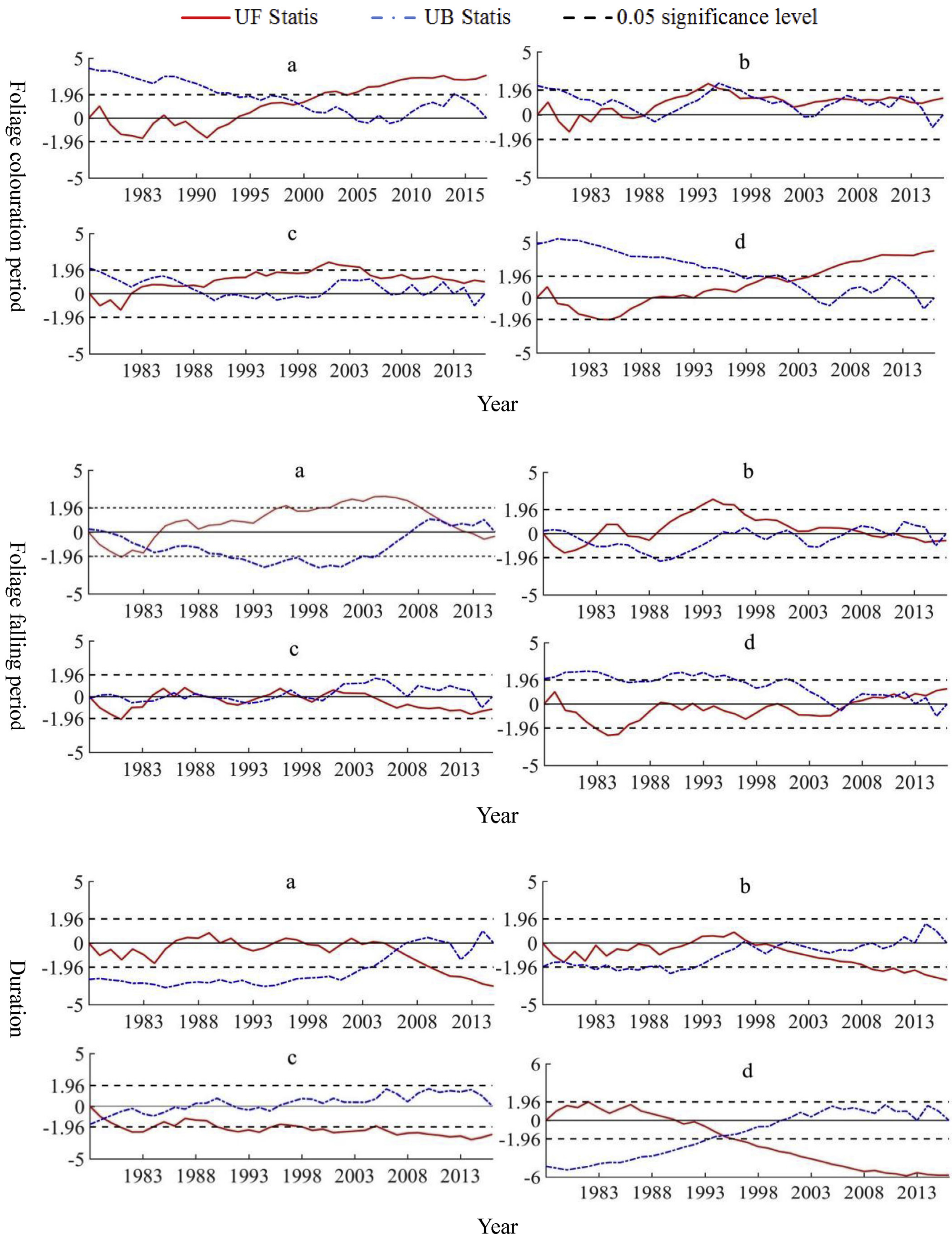

Fig. 3. Mann-Kendall detection method (M-K method) statistic curves for autumn foliage phenology from 1978 to 2016. UF, UB are their positive and negative variable tendency respectively; a, b, c, d denote Kofu, Nagoya, Okayama, and Takamatsu respectively.

Table 4
Seemingly unrelated regression (SUR) estimates of impact of phenology indicators on tourists in December.

Tourist	Kofu_SKV		Kofu_AP		Nagoya_SG		Nagoya_HZBG		Okayama_K		Takamatsu_RP	
	coef.	t	coef.	t	coef.	t	coef.	t	coef.	t	coef.	t
Colouring	2.67***	4.32	2.18***	5.72	−0.31	−0.69	−1.09	−1.44	1.44***	17.69	1.62***	6.91
Colouring (−1)	1.48***	3.72	−0.11	−0.43	2.50***	7.96	1.56***	2.57	0.45***	4.23	−0.15	−0.61
Constant	−0.09	−0.71	−0.09	−1.67	0.04	0.63	0.03	0.46	0.01	0.28	0.00	0.29
	weighted	unweighted										
R-squared	0.92	0.25										
Prob (F-statistic)	0.00											
Falling	3.68**	2.29	1.50***	4.22	1.28***	3.55	0.64	0.84	1.52***	7.39	1.93***	5.82
Falling (−1)	2.31	0.85	0.66	1.32	−1.63***	−5.54	−2.57***	−3.30	0.20	0.97	0.73	1.93
Constant	−0.07	−0.63	−0.08	−1.29	0.02	0.35	0.00	−0.01	0.00	−0.02	0.01	0.81
	weighted	unweighted										
R-squared	0.80	0.38										
Prob (F-statistic)	0.00											
Duration	0.02	0.26	−0.07***	−3.51	−0.14	−1.02	−0.08*	−1.76	0.14***	11.08	−0.09***	−4.13
Duration (−1)	−0.08	−0.61	0.11**	2.73	−0.66**	−4.19	−0.75***	−17.98	−0.03	−1.66	−0.24***	−10.30
Constant	−0.10	−0.72	−0.07	−1.25	0.00	0.14	−0.01	−0.52	0.00	0.09	0.01	0.29
	weighted	unweighted										
R-squared	0.98	0.34										
Prob (F-statistic)	0.00											

*,**,*** indicate significance at the 10, 5% and 1% levels, respectively.

Takamatsu began to change in 2007, 2001, 1979, and 1995 respectively, and their durations were significantly shortened starting from 2009, 2001, 2006, and 1996 respectively (Fig. 3).

5.2. Effect of changes in maple foliage colouration period on volume of maple viewing tourism

The autumn foliage colouration period had a significant impact on December tourism volume, and the delayed in the foliage colouration period resulted in an increase in tourism volume in December (Table 4). In the six scenic maple spots, if the foliage colouration period of the year was delayed by 1 day, the four scenic areas experienced an average increase of 3.64% in tourism volume. Specifically, Shosen kyo Valley and Okayama Korakuen were the most and least affected by the change in the autumn foliage colouration period, respectively. A 1 day delay in the foliage colouration period increased the December tourism volume in Shosen kyo Valley and Okayama Korakuen by 4.36% and 2.44%, respectively.

Changes in the autumn foliage colouration period of the previous year also had an impact on tourist volume (Table 4). A 1 day delay in the previous year's foliage colouration period of a city led to an average increase of 2.40% in tourist volume in December of the current year in four scenic spots. Specifically, Shirotori Garden and Okayama Korakuen were the most and least affected by the change in the foliage colouration period of the previous year. Furthermore, a 1 day increase in the previous year's foliage colouration period increased the tourist volume in Shirotori Garden and Okayama Korakuen by 4.40% and 0.76%, respectively.

A delay in the leaf-falling period similarly increased the December tourist volume (Table 4). When the leaf-falling period was delayed by 1 day, the December tourist volume in all scenic areas, except for Higashiyama Zoo and Botanical Gardens, increased by an average of 3.02%. In particular, the effect of the leaf-falling period of the current year had the most and least significant impacts on Shosen kyo Valley and Shirotori Garden, respectively. A 1 day delay in the leaf-falling period increased the December tourism volume in Shosen kyo Valley and Shirotori Garden by 5.33% and 1.87%, respectively. However, the leaf-falling period of the previous year had a significantly negative impact on the two scenic spots in Nagoya. That is, with the leaf-falling period of the previous year delayed by 1 day, the December tourist volume of Shirotori Garden and Higashiyama Zoo and Botanical Gardens decreased by 2.39% and 3.76%, respectively.

The duration of foliage colouration also significantly affected the December tourist volume of most autumn foliage scenic spots (Table 4). The shortened foliage colouration duration increased the tourist volume of most scenic spots. The 1 day reduction in the duration in that year caused an increase of 0.43% on average in all three areas in December, and Ritsurin Park was the most affected, the 1 day reduction in duration resulted in an increase of 0.64% in December. A 1 day reduction in the foliage colouration duration of the previous year led to an increase of 4.50% on average in all three areas in December, with Higashiyama Zoo and Botanical Gardens exhibiting the highest effect with an increase of 5.48%.

Phenophase changes in maple leaves did not have a significant effect on the November tourist volume, and the effects on most of the different spots were not uniform (Table 5). The effect of the leaf-falling period was more widespread on the November tourist volume for maple foliage viewing. The coefficient of the influence of the current year and the previous year's leaf-falling period on tourist volume in the art park in November was positive, that is, an early leaf-falling decreased the number of tourists in November. Nagoya's two spots were negatively affected by the leaf-falling period of the current year and the year before; the advanced leaf-falling period increased the number of tourists in November (Table 5).

5.3. Regional difference in effect of change of maple foliage colouration period on volume of maple foliage viewing tourists

The correlations between regression residuals of December tourist volume and autumn foliage colouration periods revealed that most scenic areas rejected the null hypothesis of independent residuals (Table 6). This indicates that when the impact of phenophase volatility on tourist volume was considered, the tourist volume fluctuations between the scenic spots were related to each other, which also shows that SUR was more effective than the OLS was. The correlations between Shosen kyo Valley and Art Park in Kofu City, Shirotori Garden, and Higashiyama Zoo and Botanical Garden in Nagoya were both 0.86, and the correlation between the two tourist spots in the same area was the strongest.

The results of the SUR showed that two spots in the same city were similarly affected by maple foliage phenophase (Tables 4 and 5). The two tourist attractions in Kofu were mainly positively affected by the

Table 5
Seemingly unrelated regression (SUR) estimates of impact of phenology indicators on tourists in November.

Tourist	Kofu_SKV		Kofu_AP		Nagoya_SG		Nagoya_HZBG		Okayama_K		Takamatsu_RP	
	coef.	t	coef.	t	coef.	t	coef.	t	coef.	t	coef.	t
Colouring	2.39	0.88	0.07	0.08	−1.17	−1.69	−1.37	−1.95	0.72**	2.22	−0.22**	−2.05
Colouring (−1)	0.76	0.27	1.19	1.36	0.97	1.82	−0.24	−0.34	0.11	0.31	0.07	0.73
Constant	−0.12	−0.92	−0.07	−1.27	0.07**	2.08	0.02	0.69	0.01	0.61	0.01	0.83
	weighted	unweighted										
R-squared	0.71	0.18										
Prob (F-statistic)	0.00											
Falling	4.09**	2.41	2.04**	2.65	−1.46**	−2.49	−0.94***	−3.54	−0.03	−0.06	−0.20	−1.99
Falling (−1)	4.14	1.43	4.12***	3.26	−1.66**	−2.60	−1.84***	−7.01	−0.39	−0.68	0.32**	2.66
Constant	−0.09	−0.71	−0.03	−0.66	0.05	1.78	0.00	−0.08	0.02	0.71	0.01	1.95
	weighted	unweighted										
R-squared	0.85	0.34										
Prob (F-statistic)	0.00											
Duration	0.16	0.26	0.08*	0.07	−0.20**	0.02	0.11	0.32	−0.21***	0.00	−0.01	0.45
Duration (−1)	0.25	0.11	−0.05	0.29	−0.24***	0.01	−0.10	0.38	−0.21***	0.00	0.07***	0.00
Constant	−0.10	−0.73	−0.08	−1.32	0.05	1.61	0.01	0.38	0.03	1.49	0.01	1.53
	weighted	unweighted										
R-squared	0.79	0.20										
Prob (F-statistic)	0.00											

*,**,*** indicate significance at the 10, 5% and 1% levels, respectively.

phenophase of the current year while that of Nagoya was mainly negatively affected by the phenophase of the previous year. A delay in the maple foliage colouration period of the current year increased the number of tourists in Shosen kyo Valley and the Art Park in Kofu in December. A delay in the maple leaf-falling period of the current year increased the number of tourists at both sites during November and December. A delay or shortened duration of maple leaf-falling in the previous year increased the number of tourists at Shirotori Garden and Higashiyama Zoo and Botanical Gardens during November and December. A delay in the maple colouration period of 1 day in the previous year increased the number of tourists at both sites in December.

The tourist volume in both scenic spots in Kofu was more affected by changes in maple phenophase than that of other spots. In particular, the tourist volume in Shosen kyo Valley was most significantly affected by changes in maple phenophase. A delay in the foliage colouration period of 1 day in the current year increased the December tourist volumes of Shosen kyo Valley and the Art Park by 4.36% and 3.57%, respectively. A 1 day delay in the leaf-falling period of the current year increased the total November and December tourist volumes of Shosen kyo Valley and the Art Park by 5.82% and 2.71%, respectively.

6. Discussion and management implications

6.1. Discussion

From an economic point of view, red leaf tourism is a "hot spot" in the global tourism industry, which can be seen from the data on the number of tourists and tourist spending in attractions around the world. Annually, New Hampshire, United States, receives 8.2 million tourists for red leaf viewing and tourism revenues of USD $1 billion (http://www.businessinsider.com/new-england-tourists-spend-billions-2014-10/?IR=T). In Beijing, China, Xiangshan Park alone attracts more than 1 million tourists each year (Ge et al., 2013). There are 100 roads for viewing autumn leaves in Seoul, the capital of South Korea (http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_6.jsp?cid=261031). Clearly, with the ever-increasing popularity of red leaf viewing tourism around the world, the demand for studies to cope with climate change effects on red leaf tourism is increasingly urgent. However, few papers explore the theme of tourism and climate change. Due to the complexity of plant phenological changes in autumn, the patterns of foliage colouration periods and the sensitivity of plant phenological phases to temperature significantly differs across various regions (Estiarte & Peñuelas, 2015). To understand the impact of climate change on red leaf tourism and provide coping strategies, it is necessary to conduct specific studies in typical regions where red leaf tourism is well developed and climate change is significant.

Autumn foliage colouration and leaf-falling periods are the two key phenological changes that affect maple foliage viewing tourist volume. However, the plant phenophase of different seasons may have opposing effects on human tourism activities. This study revealed that delayed foliage colouration periods increased the maple foliage viewing tourist volume, and Sakurai et al., 2011 found that early springtime flowering reduced the flowering viewing tourist volume. Whether delayed or early plant phenology trends have opposing effects on plant viewing tourism activities remains to be verified by additional studies. In addition, compared to the uniform trend in spring plant phenophase changes, the autumn trend was not uniform. We found that unlike autumn foliage colouration periods that were significantly delayed, the change leaf-falling periods were not significant, and only one city experienced a significant delay in the leaf-falling period. This reflects the complexity of autumn phenology changes. Therefore, the phenophase trends in maple foliage and impact on the pattern of tourist volume also

Table 6
Correlations of tourists in November with the date of leaf colouring based on seemingly unrelated regression (SUR) method.

	Kofu_SKV	Kofu_AP	Nagoya_SG	Nagoya_HZBG	Okayama_K	Takamatsu_RP
Kofu_SKV	1.00					
Kofu_AP	0.86	1.00				
Nagoya_SG	−0.09	−0.34	1.00			
Nagoya_HZBG	0.32	−0.05	0.86	1.00		
Okayama_K	0.71	0.54	0.59	0.77	1.00	
Takamatsu_RP	0.39	0.51	0.31	0.42	0.65	1.00

need to be comparatively analysed in more areas.

Considering the mechanism underlying this effect, not only do the autumn foliage colouration and leaf-falling periods of the current year affect the maple foliage viewing tourist volume, but it also had a simultaneous 1 year delay effect. However, the effects of the current and previous years' leaf-falling period on tourist volume are opposite. The delay in the leaf-falling period of the current year increased the tourist volume, but a delay in the previous years' leaf-falling period decreased the tourist volume. Lag effects have also been demonstrated in some studies that analysed the impact of climatic factors on the number of tourists (Falk, 2014; Windle & Rolfe, 2013). However, the impact of climatic factors on the current and following year is consistent to different degrees. This also shows that the impact of autumn plant phenophase on tourist volume is indeed relatively complicated. In addition, this also shows that more data and information are needed to further elucidate the mechanisms by which the phenophase affects tourist volume.

The shortened autumn foliage colouration duration increased the tourist volume for most scenic spots. In general, a shorter duration means tourists have less time to participate in maple foliage viewing tours and decreased the tourist volume. There are two possible reasons for this. First, it is possible that there may be a threshold for the impact of the change in the phenophase on the tourist volume. That is, continued reduction in the duration to a certain extent would make the impact on tourist volume appear significant. Considering the effect of the threshold temperature on phenology such as the plant flowering period, clearly identifying this threshold is a focus of future research. Second, the increase in public demand for tourism has led to a continued increase in the number of tourists, especially in Japan with an increasing amount of tourist visiting during the autumn season (https://www.yamatogokoro.jp/report/8272/). This may counter the effect of shortened autumn foliage colouration duration on decreasing tourist volume. This requires developing some suitable methods in future research to eliminate the trend of increasing demand.

6.2. Management implications

The fluctuations in the foliage colouration period have affected maple leaf tourism activities. In addition to these fluctuations, other indices in relation to the quality of maple leaf landscapes may also change, such as the colours and colour saturation of maple leaves. Japan currently has standardised and long-term maple leaf colouration period observations, but no observations and records for the colour saturation and colours of maple leaves. Therefore, in addition to recording the foliage colouration period, observation stations should introduce the "Royal Colour Charts" in the major maple leaf viewing tourism areas to accurately compare the differences in foliage colours across different years.

There are differences between the sensitivity of maple leaves in various scenic areas to climate change and the impact of changes in the viewing period of maple leaves on the number of tourists. The government should prioritise assessing the impact of climate change on a national scale. In particular, the sensitivity of maple leaves to climate change should be comprehensively assessed, and studies and monitoring should be conducted in scenic areas that are particularly highly sensitive to climate change. The government should promote the spread of knowledge on climate change and its impact on tourists and tourism area operators to increase the awareness of stakeholders on climate change and its impact. This will lay a foundation for the follow-up promotion of climate change adaptation strategies.

Because maple leaf tourism in autumn is a popular activity around the world, and the response of phenological phases, such as foliage colouration, to climate change is complicated, international cooperation should be strengthened in this field. The focus should be the extensive data sharing among research institutions in different countries and regions to provide data support for scientific and comprehensive assessment and comparison of the impact of climate change. On this basis, international collaborative research projects should be initiated to develop cooperation in forecasting models and evaluation methods, thereby improving the reliability of assessment results. Finally, countries around the world could collect and share many validated and effective models of tourism responses to climate change for demonstration and promotion in similar regions.

7. Conclusion

The results showed that between 1978 and 2016, the climate change in four cities in Japan caused a delay in autumn foliage colouration change and shortened the duration of leaf colouration. However, only one city, Takamatsu, experienced a significant delay in leaf-falling. Overall, the change in the timing of maple leaf discolouration has been advantageous to the Japanese maple tourism industry. During the autumn foliage colouration period, the delay in the leaf-falling period will on average increase the December maple viewing tourism volume by 3.28% and 2.90%. Foliage phenophase has a 1 year delayed effect on maple foliage viewing tourist volume, but the effect of the foliage colouration and leaf-falling periods on tourist volume varied in significance. Every day the previous year's foliage colouration period was delayed led to a 2.58% increase in the December tourist volume in the current year. However, every day the previous year's leaf-falling period was delayed decreased the December tourist volume of Shirotori Garden and Higashiyama Zoo and Botanical Gardens by 2.39% and 3.76%, respectively in the current year. The shortened autumn foliage colouration duration increased the tourist volume for most scenic spots. The maple foliage phenophase of different cities have significantly varied influence on maple foliage viewing tourism volume.

There are some limitations to the present study.First, the number of cities involved in this study is limited. This is because we only selected study observation sites for which there are both monthly tourist data and phenological observation data for the study timeline. In Japan, observation data of plant phenology is relatively comprehensive, but many tourist destinations do not disclose monthly tourist data; therefore, only six scenic spots met the study's needs. It would take both more time and phenology and tourist data to comprehensively evaluate the response of Japanese maple leaf tourism to climate change. We hope that our article can attract the attention of the governments and scenic area managers to promote the sharing of tourist data in the future.

In addition, this study mainly discussed the impact of changes in foliage phenology caused by climate change on the number of tourists, but lacked research on the interactions between tourist attractions. Climate change will not only increase the likelihood of tourists missing the best sightseeing periods, but affect the quality of future red leaf landscapes and reduce the attractiveness of scenic spots, thus fundamentally changing the spatial distribution pattern of red leaf tourism. Phenological observation stations need to reinforce the observation and recording of standardised maple leaf colour and saturation, and combine such data with tourist volumes within the same timeframe to analyse the influence of the changes in the landscape quality caused by climate change on maple leaf tourism.

Author contributions

J.L conceived and designed the research; H.C, D. J collected and analysed the data; L.H wrote limitation and management implication; all authors wrote and reviewed the paper.

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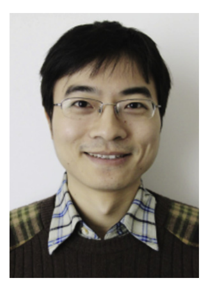
References

Amelung, B., & Moreno, A. (2012). Costing the impact of climate change on tourism in euro pe: Results of the peseta project. *Climatic Change, 112*(1), 83–100.
Atzori, R., Fyall, A., & Miller, G. (2018). Tourist responses to climate change: Potential impacts and adaptation in Florida's coastal destinations. *Tourism Management, 69*, 12–22.
Camille (2013). Impact of snow variability on the Swiss winter tourism sector:;implications in an era of climate change. *Climatic Change, 119*(2), 307–320.
Doi, H., & Takahashi, M. (2008). Latitudinal patterns in the phenological responses of leaf colouring and leaf fall to climate change in Japan. *Global Ecology and Biogeography, 17*(4), 556–561.
Dawson, J., & Scott, D. (2013). Managing for climate change in the alpine ski sector. *Tourism Management, 35*(4), 244–254.
Estiarte, M., & Peñuelas, J. (2015). Alteration of the phenology of leaf senescence and fall in winter deciduous species by climate change: Effects on nutrient proficiency. *Global Change Biology, 21*(3), 1005–1017.
Falk, M. (2014). Impact of weather conditions on tourism demand in the peak summer season over the last 50 years. *Tourism Management Perspectives, 9*(Complete), 24–35.
Falk, M. (2015). Summer weather conditions and tourism flows in urban and rural destinations. *Climatic Change, 130*(2), 201–222.
Falk, M., & Hagsten, E. (2016). Importance of early snowfall for Swedish ski resorts: Evidence based on monthly data. *Tourism Management, 53*, 61–73.
Fan, C., Liu, J., & Quansheng, G. E. (2017). Pulling vs. pushing: Effect of climatic factors on periodical fluctuation of Russian and South Korean tourist demand in Hainan Island, China. *Chinese Geographical Science, 27*(4), 648–659.
Gunderson, C. A., Edwards, N. T., Walker, A. V., O'Hara, K. H., Campion, C. M., & Hanson, P. J. (2012). Forest phenology and a warmer climate – growing season extension in re lation to climatic provenance. *Global Change Biology, 18*(6), 2008–2025.
Ge, Q. S., Dai, J. H., Liu, J., Zhong, S. Y., & Liu, H. L. (2013). The effect of climate change on the fall foliage vacation in China. *Tourism Management, 38*(38), 80–84.
Gallinat, A. S., Primack, R. B., & Wagner, D. L. (2015). Autumn, the neglected season in climate change research. *Trends in Ecology & Evolution, 30*(3), 169–176.
Goldberg, J., Marshall, N., Birtles, A., Case, P., Bohensky, E., Curnock, M., et al. (2016). Climate change, the great barrier reef and the response of australians. *Chronicle, 2*(9), 15046.
Hewer, M. J., & Gough, W. A. (2017). *Thirty years of assessing the impacts of climate change on outdoor recreation and tourism in Canada. Tourism Management Perspectives*.
Hassanali, K. (2017). Challenges in mainstreaming climate change into productive coastal sectors in a small island state – the case of Trinidad and Tobago. *Ocean & Coastal Management, 142*, 136–142.
Ibanez, I., Primack, R. B., Miller-Rushing, A. J., Ellwood, E., Higuchi, H., Sang, D. L., et al. (2010). Forecasting phenology under global warming. *Philosophical Transactions of the Royal Society of London, 365*(1555), 3247–3260.
Inoue, T., & Nagai, S. (2015). Influence of temperature change on plant tourism in Japan: A case study of the flowering of lycoris radiata (red spider lily). *Japanese Journal of Biometeorology, 52*, 175–184.
Agency J.M. (JMA) (2007). *Long-term trends of phenological events in Japan.* https://ds.data.jma.go.jp/tcc/tcc/news/PhenologicalEventsJapan.pdf, Accessed date: February 2018.
Agency J.M. (JMA) (2017). *Climate change monitoring report 2016*http://www.jma.go.jp/jma/en/NMHS/ccmr/ccmr2016_low.pdf, Accessed date: October 2017.
Klein, G., Vitasse, Y., Rixen, C., Marty, C., & Rebetez, M. (2016). Shorter snow cover duration since 1970 in the Swiss alps due to earlier snowmelt more than to later snow onset. *Climatic Change, 139*, 1–13.
Liu, Q., Fu, Y. H., Zhu, Z., Liu, Y., Liu, Z., Huang, M., et al. (2016). Delayed autumn phenology in the northern hemisphere is related to change in both climate and spring phenology. *Global Change Biology, 22*(11), 3702–3711.
Liu, J., Han, C., Xiaoqian, S., Li, H., Qiuchan, F., & Haolong, L. (2017). Effects of climate change on outdoor skating in the Bei Hai Park of Beijing and related adaptive strategies. *Sustainability, 9*, 1147.
Malatinszky, Á., Ádám, S., Falusi, E., Saláta, D., & Penksza, K. (2013). Climate change related land use problems in protected wetlands: A study in a seriously affected Hungarian area. *Climatic Change, 118*(3–4), 671–682.
Mackintosh, A. N., Anderson, B. M., Lorrey, A. M., Renwick, J. A., Frei, P., & Dean, S. M. (2017). Regional cooling caused recent New Zealand glacier advances in a period of global warming. *Nature Communications, 8*, 14202.
Ozturk, I. (2017). Measuring the impact of alternative and nuclear energy consumption, carbon dioxide emissions and oil rents on specific growth factors in the panel of Latin american countries. *Progress in Nuclear Energy, 100*, 71–81.
Piao, S., Tan, J., Chen, A., Fu, Y. H., Ciais, P., Liu, Q., et al. (2015). Leaf onset in the northern hemisphere triggered by daytime temperature. *Nature Communications, 6*, 6911.
Pacheco, L. (2016). Revpar determinants of Portuguese hotels: The global and the local factors. *Tourism, 64*(2), 219.
Richardson, A. D., Keenan, T. F., Migliavacca, M., Ryu, Y., Sonnentag, O., & Toomey, M. (2013). Climate change, phenology, and phenological control of vegetation feedbacks to the climate system. *Agricultural and Forest Meteorology, 169*(3), 156–173.
Rutty, M., Scott, D., Johnson, P., Pons, M., Steiger, R., & Vilella, M. (2017). Using ski industry response to climatic variability to assess climate change risk: An analogue study in Eastern Canada. *Tourism Management, 58*, 196–204.
Sakurai, R., Jacobson, S. K., Kobori, H., Primack, R., Oka, K., Komatsu, N., et al. (2011). Culture and climate change: Japanese cherry blossom festivals and stakeholders' knowledge and attitudes about global climate change. *Biological Conservation, 144*(1), 654–658.
Sparks, T. H. (2014). Local-scale adaptation to climate change: The village flower festival. *Climate Research, 60*(1), 87–89.
Schliephack, J., & Dickinson, J. E. (2017). Tourists' representations of coastal managed realignment as a climate change adaptation strategy. *Tourism Management, 59*, 182–192.
Thrane, C. (2015). Students' summer tourism: An econometric analysis of trip costs and trip expenditures. *Tourism Management Perspectives, 15*, 65–71.
Tao, Z., Ge, Q., Wang, H., & Dai, J. (2015). Phenological basis of determining touris m seasons for ornamental plants in central and eastern China. *Journal of Geographical Sciences, 25*(11), 1343–1356.
Toimil, A., Díaz-Simal, P., Losada, I. J., & Camus, P. (2018). Estimating the risk of loss of beach recreation value under climate change. *Tourism Management, 68*, 387–400.
Vitasse, Y., François, C., Delpierre, N., Dufrêne, E., Kremer, A., Chuine, I., et al. (2011). Assessing the effects of climate change on the phenology of european temperate trees. *Agricultural and Forest Meteorology, 151*(7), 969–980.
Windle, J., & Rolfe, J. (2013). The impacts of the 2011 e xtre me weather events on holiday choices of brisbane residents. *Australasian Journal of Environmental Management, 20*(4), 338–350.
Wang, L., Ning, Z., Wang, H., & Ge, Q. (2017). Impact of climate variability on flowering phenology and its implications for the schedule of blossom festivals. *Sustainability, 9*(7), 1127.
Intergovernmental Panel on Climate Change (IPCC) (2014). *Climate change 2014 mitigation of climate change.* http://www.ipcc.ch/report/ar5/syr/, Accessed date: October 2017.
Japan Meteorological website, http://tenki.wet.co.jp/kisetsu/index.html. (Accessed February 2018).
Japan Maple Tours website (2017), http://www.nihon-kankou.or.jp/kouyou/ (Accessed May 2018).
Kagaw OfficiaTourism Websitel (2016). *Kagawa prefecture visitors Dynamics investigation reports*https://www.my-kagawa.jp/research/feature/top/research, Accessed date: July 2017.
Business insider (2014), http://www.businessinsider.com/new-england-tourists-spend-billions-2014-10/?IR = T (Accessed October 2014).
Visit korea (2017), http://english.visitkorea.or.kr/enu/ATR/SI_EN_3_6.jsp?cid = 261031 (Accessed November, 2017, Korea Tourism Organization).



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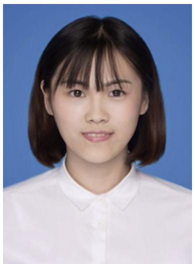

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